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UNIVERSITY OF TEXAS

1915 NO. 1

JANUARY 1

Annual Flow and Run-Off of Some Texas Streams

BY

T. U. TAYLOR

PROFESSOR OF CIVIL ENGINEERING

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Published by the University six times a month and entered as second class matter at the postoffice at Austin, Texas

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston.

Cultivated mind is the guardian genius of democracy.....It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar.

ANNUAL FLOW AND RUN-OFF OF SOME TEXAS STREAMS.

By T. U. Taylor, M. C. E.

The run-off from any water shed in the west depends upon the following factors:

1. Size of catchment area of water shed.
2. Mean Rainfall.
3. Regularity of the Flow.
4. Amount lost by seepage.
5. Amount used for Irrigation.

The area of the water shed can be ascertained with a reasonable degree of accuracy and the regularity of flow can be ascertained by the construction of hydrographs based upon daily records of gauge heights and flow measurements. These can only be obtained by establishing gauging stations with observations daily upon the stage of the height of the river and by taking a sufficient number of measurements to establish or determine a rating curve or rating table.

The regularity of the flow, the mean flow per day, the mean monthly flow, and the mean annual flow, are data that can be obtained only by careful observations and measurements for the station and stream concerned. The writer for the last eighteen years has made observations of measurements upon the Colorado river at Austin, Texas, and on many other rivers of Texas since 1896. Measurements have been taken on the Colorado, at Austin, and at Columbus, Texas, on the Brazos river at Waco, and on the Trinity at Dallas and Riverside, Texas.

The results of these observations and measurements are given in the tables that follow. Each year required 365 gauge height readings, and to obtain the mean daily discharge of the water in second-feet, a rating curve or rating table was generally obtained by visiting the station at its highest flood, and then taking systematic measurements by current meters as the level of the water fell. Each station required 365 field observations for gauge heights and then 365 observations again to translate these gauge heights readings by use of the rating table into daily discharges. After the daily discharges were obtained the gross sum of the 365 mean daily discharges were added and the mean or average dscharge per second for the year was obtained. Thus each year required over 1095 observations. The Colorado at Austin for the last eighteen years required the handling of over 19,500 separate records, while the station at Columbus for the years covered required 10,950 operations. The Brazos at Waco required over 16,300 records, the Trinity at Dallas over 9,950, the Trinity at Riverside over 12,000 records. Thus the three rivers and the five stations reported on in the following tables required the handling of over 68,000 records and operations. The writer has been personally through all of these records and has had them verified, but the work has spun out over many years, ''watching and waiting.''

It will be observed that the present run-off of the Trinity at Riverside is much greater than that at any other station. The Colorado is very low in percentages on account of the fact that possibly one-third of its drainage reaches into the staked plains and it is a rare occurrence when any of the water that falls along the Texas and Pacific Railway near the corner of New Mexico reaches Austin. The Brazos also reaches up into the plains country where the rainfall is slight and the ground thirsty and generally ready to drink up an ordinary rainfall. In the case of the Trinity at Riverside, the percents of run-off are much greater than those at Austin or Waco. This is on account of the fact that the Trinity for many miles above Riverside, in fact nearly all the way from Dallas, passes through a wooded country that is somewhat even in its topography. The result is that the leaves serve to hold the moisture and the soil does not become so dry and thirsty. A small per cent is absorbed by the soil. Generally there is a better ''season'' in the ground in East Texas than in the more westerly portions.

Where the water-shed is not long drawn out and is located entirely in a canyon or mountainous section, we may expect much greater run-offs than can be obtained for rivers of longer length traversing wholly, or in part, flat sections of country. One thing that makes the per cent of run-offs of the Colorado at Austin, small or low, is the fact that a large section of the water-shed area is in the staked plains or in reasonably flat sections of country from Ballinger west and northwest. The run-offs of the canyon section of the Colorado would be in excess of those given in the table. The run-off of the Guadalupe above New Braunfels would be much greater than that of a river of equal length, equal water-shed area, and equal rainfall located in a flatter, or agricultural section.

In the Medina water-shed we can legitimately expect a run-off much in excess of that of the Colorado for equal rain falls on account of the fact that the water-shed above the Medina Dam is located in the Edwards Plateau, which is not only hilly but largely wooded or grazing, a relatively small per cent of which is agricultural.

CALCULATIONS RUN-OFF IN INCHES

Let X=the depth of rainfall in inches on the whole water shed that would give the mean annual flow at a station on the assumption that none of it was lost by seepage, evaporation, irrigation or otherwise.

A=Area of the water shed in square miles.

Q=Mean discharge in cu. ft. per second.

Then for a year of 365 days, we have:

$$\frac{X}{12}\times 640\ A\times 4840\times 9=60\times 60\times 24\times 365\ Q$$

Hence:

$$X=3285\ Q\div 242\ A$$

Then for a year of 366 days, we have:

$$X=3294\ Q\div 242\ A$$

For the Colorado river above Austin, we have:

$$A=37000.$$

Substituting, we have the equation for run-off in inches:

$$X=Q\div 2726$$

Then for a year of 366 days, we have:

$$X=Q\div 2718$$

The drainage area of the Brazos above Waco is 30,800 sq. mi.

Hence for a year of 365 days, we have:

$X = 3285\ Q \div 242 \times 30800 = Q \div 2269$

For a year of 366 days, we have:

$X = 3294\ Q \div 242 \times 30800 = Q \div 2263$

The drainage area of the Trinity above Dallas has an area of 5950 sq. mi.

For a year of 365 days, we have:

$X = Q \div 438$

For a year of 366 days, we have:

$X = Q \div 437$

The area of the water shed of the Trinity above Riverside is 16000 sq. mi.

For a year of 365 days, we have:

$X = Q \div 1179$

For a year of 366 days, we have:

$X = Q \div 1176$

To obtain the run-off in inches, divide the mean annual discharge in cubic feet per second by the run-off divisor in the following table:

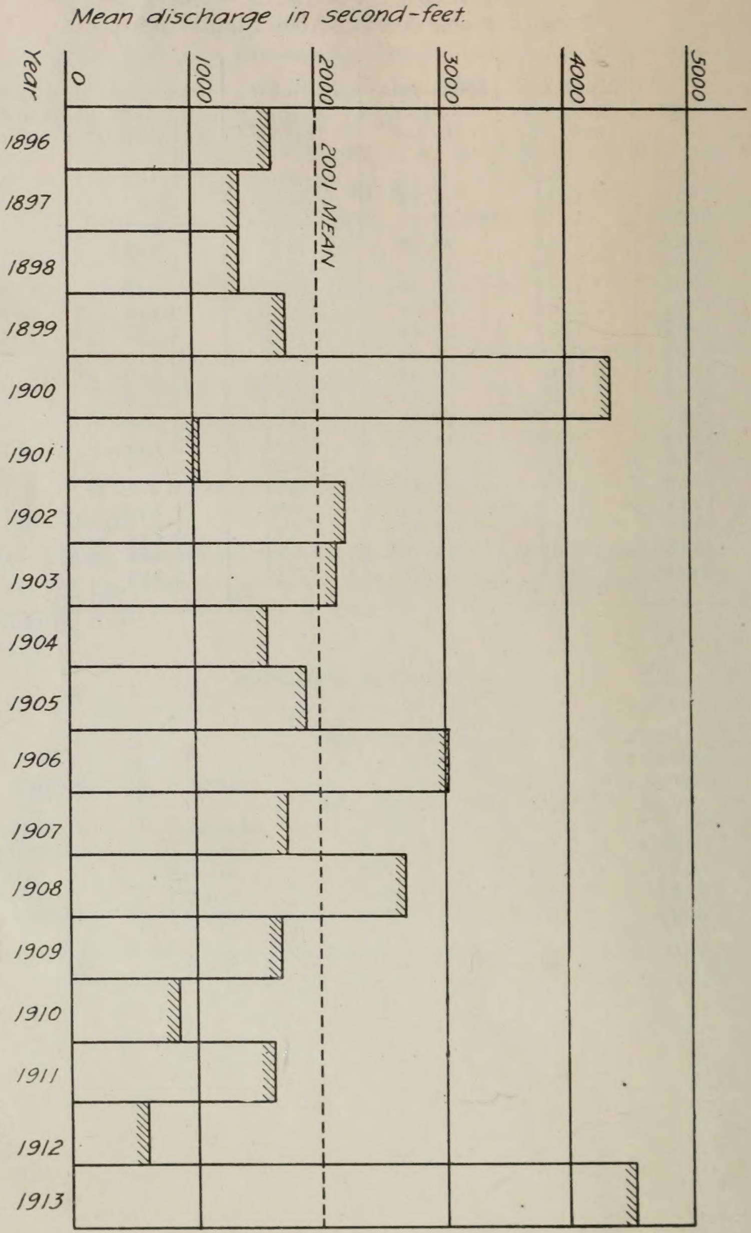
RUN-OFF DIVISOR

Station	River	Run-off divisor for a year of		Area of watershed in square miles
		365 days	366 days	
Austin	Colorado	2726	2718	37,000
Columbus	Colorado	2947	2938	40,000
Waco	Brazos	2269	2263	30,800
Dallas	Trinity	438	437	5,950
Riverside	Trinity	1179	1176	16,000

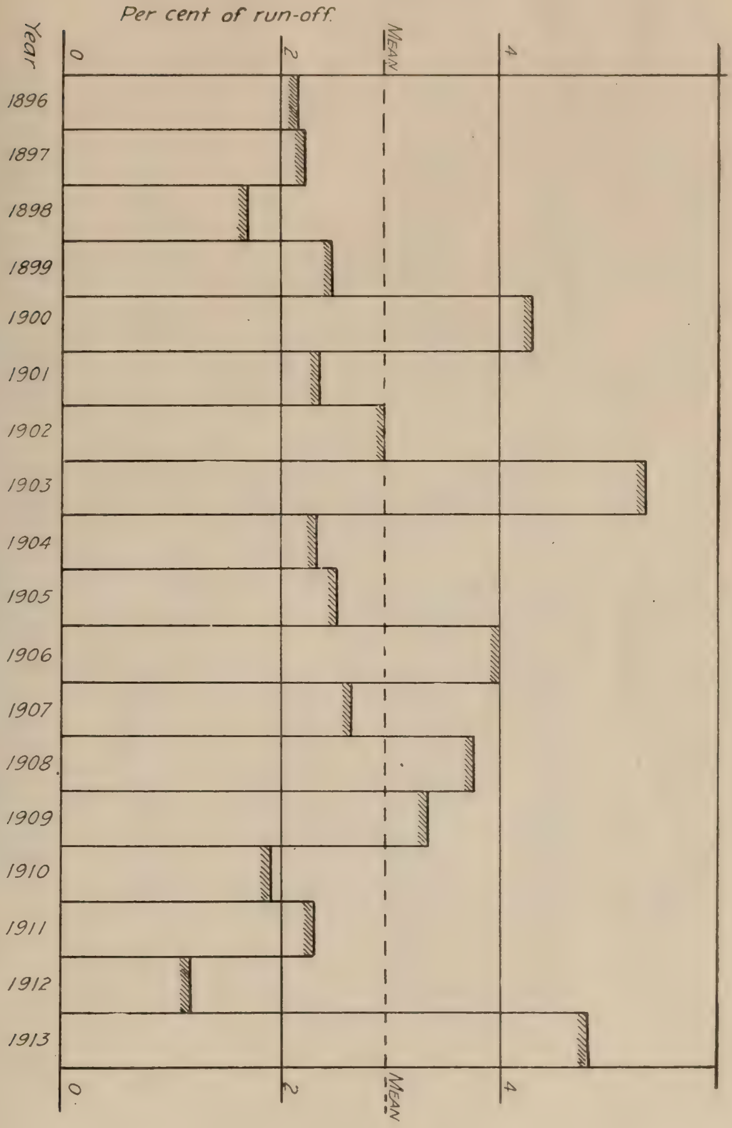
COLORADO AT AUSTIN, TEXAS

Area of Water Shed=37,000 Square Miles

Year	Mean discharge in sec. ft.	Mean rainfall in inches	Run-off in inches	Run-off in per cent of rainfall	No. of rain-fall stations
1896	1630	27.86	.600	2.154	10
1897	1390	22.63	.510	2.254	11
1898	1170	25.37	.429	1.691	11
1899	1740	26.36	.639	2.424	11
1900	4380	37.32	1.608	4.309	11
1901	1040	16.10	.381	2.366	11
1902	2224	27.66	.816	2.950	13
1903	2157	23.64	.792	5.350	14
1904	1595	25.41	.587	2.310	15
1905	1918	28.09	.704	2.506	14
1906	3060	27.84	1.123	4.034	13
1907	1740	24.33	.639	2.629	12
1908	2710	26.89	1.005	3.741	14
1909	1690	18.36	.620	3.377	13
1910	865	16.64	.318	1.911	13
1911	1540	24.14	.565	2.343	14
1912	592	17.90	.217	1.212	13
1913	4560	34.80	1.694	4.869	11
Mean	2001	25.07	.736	2.913	



MEAN DISCHARGE OF THE COLORADO RIVER AT AUSTIN, TEXAS IN SECOND-FEET.



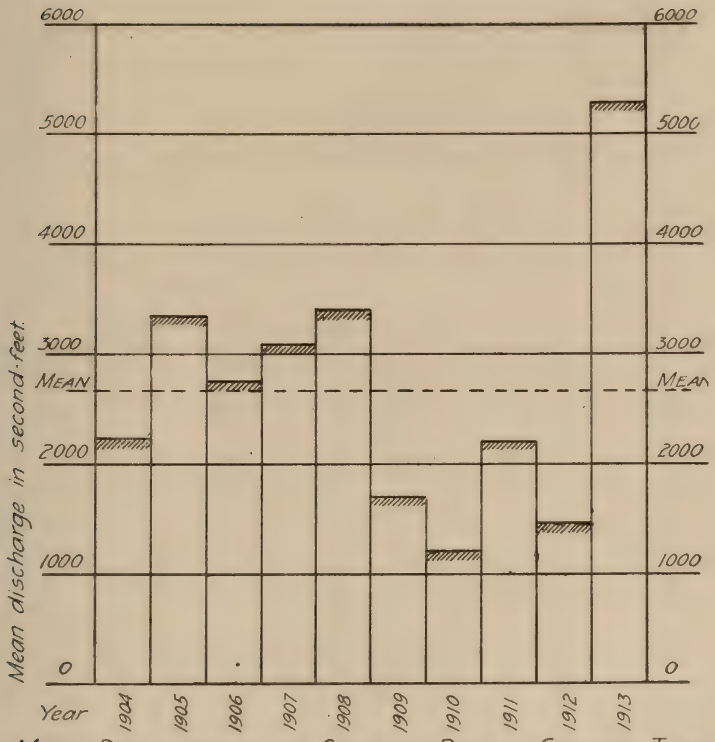
Run-Off of the Colorado River at Austin, Texas

COLORADO AT COLUMBUS, TEXAS
Area Water Shed=40,000 Square Miles

Year	Mean discharge in sec. ft.	Mean rainfall in inches	Run-off in inches	Run-off in per cent of rainfall	No. of rain-fall stations
1904	2225	25.41	.757	2.978	15
1905	3358	28.09	1.139	4.055	14
1906	2730	27.84	.926	3.326	13
1907	3090	24.33	1.049	4.318	12
1908	3400	26.89	1.157	4.306	14
1909	1690	18.36	.573	2.577	13
1910	1200	17.32	.407	2.352	14
1911	2209	25.00	.749	2.996	15
1912	1458	19.07	.496	2.603	14
1913	5280	36.06	1.792	4.978	12
Mean	2664	24.84	.905	3.45	

BRAZOS AT WACO, TEXAS
Area of Water Shed=30,800 Square Miles

Year	Mean discharge in sec. ft.	Mean rainfall in inches	Run-off in inches	Run-off in per cent of rainfall	No. of rain-fall stations
1899	2732	26.94	1.205	4.477	7
1900	4551	34.79	2.207	6.350	7
1901	839	17.39	.370	2.129	8
1902	2694	27.07	1.187	4.389	9
1903	2002	24.44	.883	3.366	9
1904	1180	22.64	.521	2.301	11
1905	3775	38.25	1.664	4.355	10
1906	2350	32.82	1.036	3.156	10
1907	1850	25.34	.816	3.220	11
1908	4340	30.63	1.918	6.268	11
1909	866	21.63	.382	1.768	11
1910	576	17.24	.254	1.458	10
1911	1297	26.15	.572	2.188	11
1912	1090	21.07	.482	2.288	11
1913	4450	31.98	1.962	6.135	8
Mean	2306	26.56	1.031	3.59	



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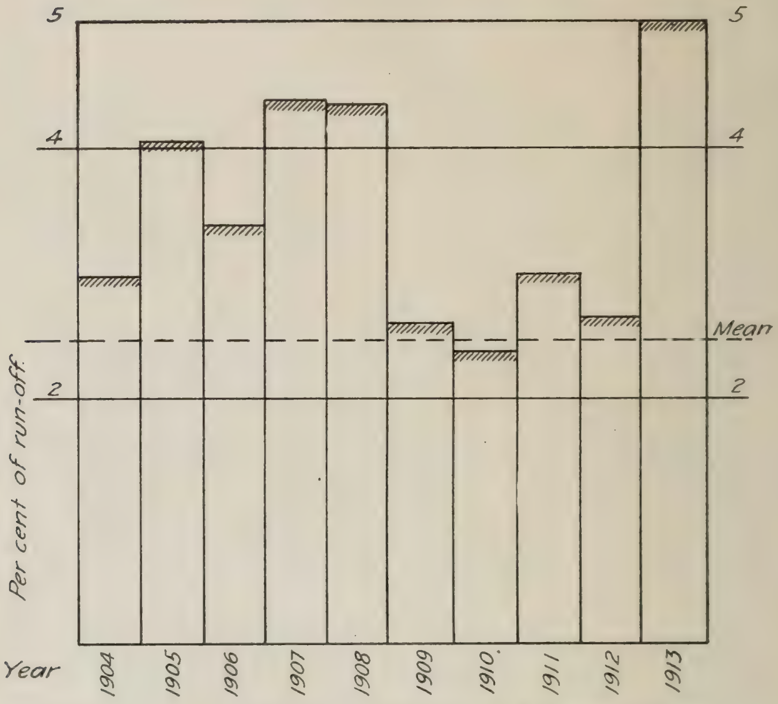
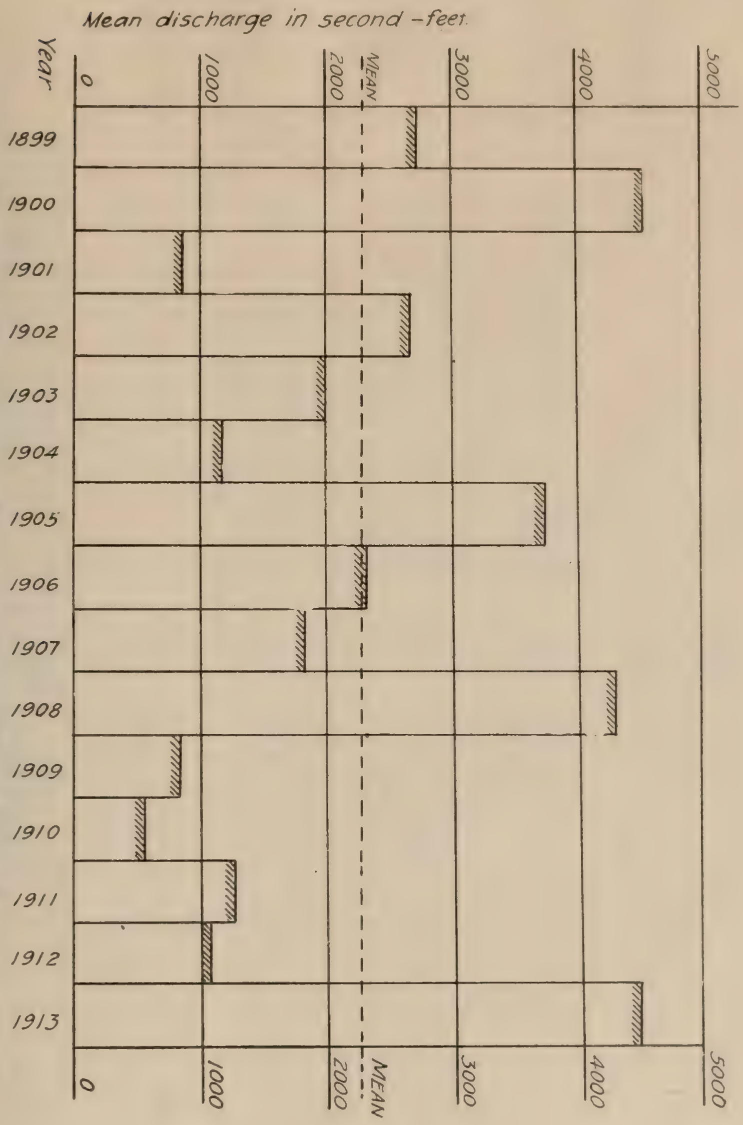


RUN-OFF OF COLORADO RIVER AT COLUMBUS, TEXAS



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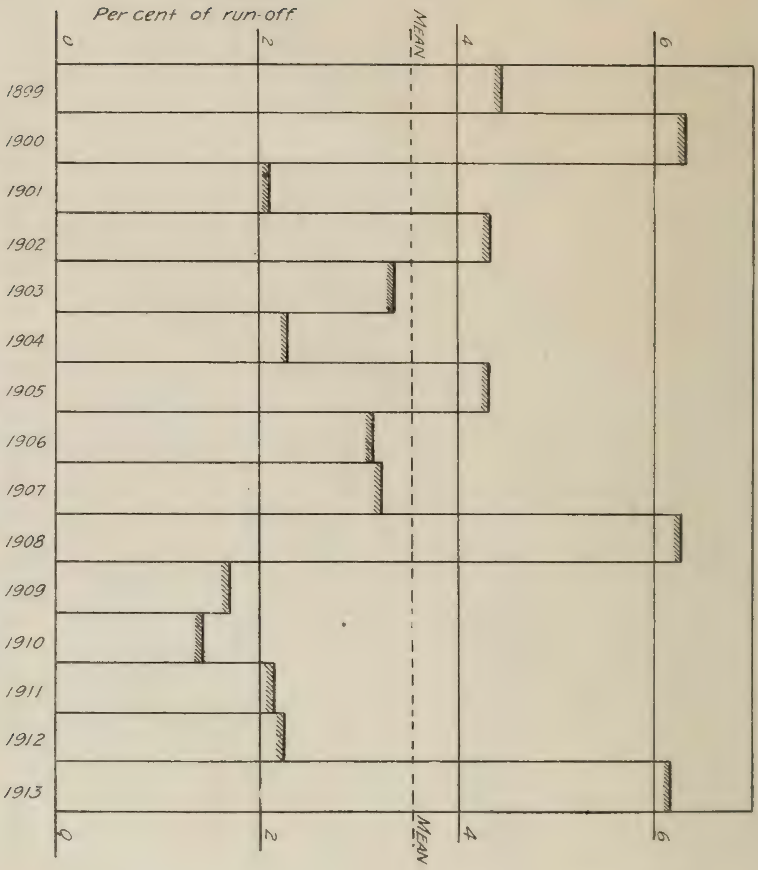


RUN-OFF OF BRAZOS RIVER AT WACO, TEXAS.

TRINITY AT DALLAS, TEXAS

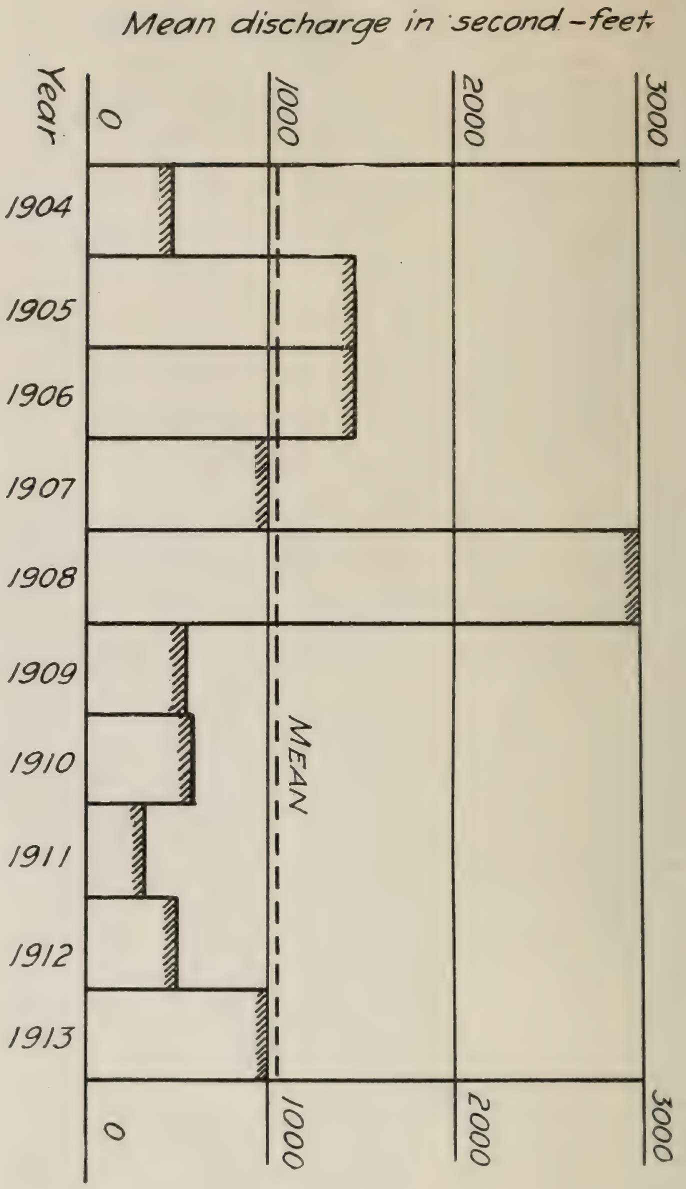
Drainage Area=5950 Square Miles

Year	Mean discharge in sec. ft.	Mean rainfall in inches	Run-off in inches	Run-off in per cent of rainfall	No. of rain-fall stations
1904	470	30.76	1.076	3.497	4
1905	1480	45.78	3.379	7.382	5
1906	1470	39.06	3.356	8.589	4
1907	993	31.49	2.207	7.199	5
1908	3068	42.62	7.021	16.477	5
1909	554	22.81	1.264	5.546	5
1910	571	21.51	1.304	6.069	4
1911	327	28.68	.746	2.602	4
1912	510	28.15	1.167	4.146	4
1913	997	37.09	2.263	6.101	4
Mean	1044	32.80	2.378	6.76	

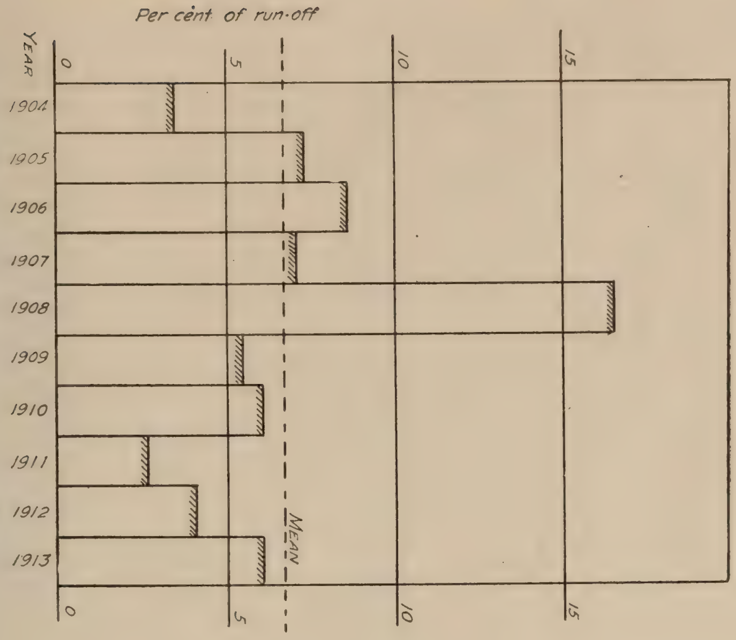
TRINITY RIVER AT RIVERSIDE, TEXAS

Area of Water Shed=16,000 Square Miles

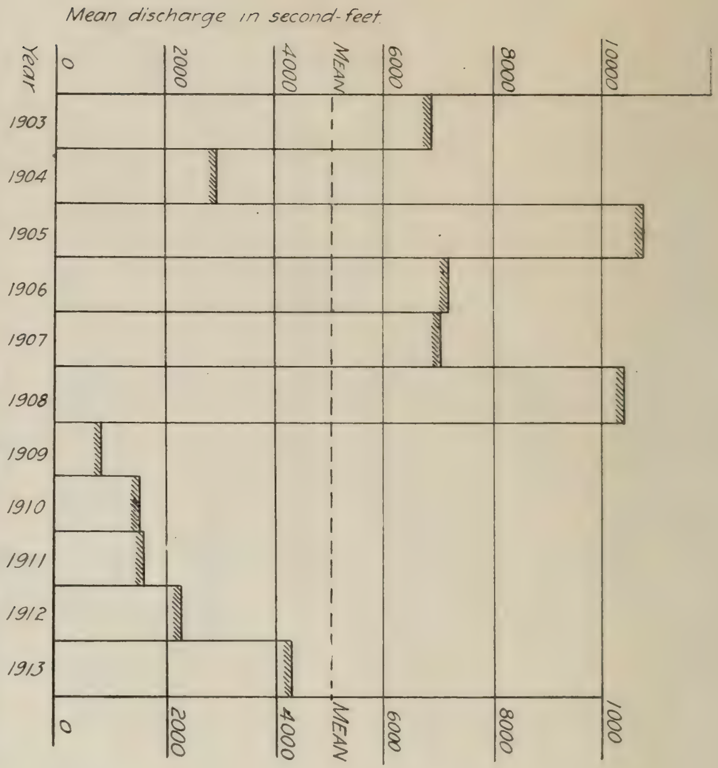
Year	Mean discharge in sec. ft.	Mean rainfall in inches	Run-off in inches	Run-off in per cent of rainfall	No. of rain-fall stations
1903	6897	36.47	5.845	16.050	8
1904	2936	32.24	2.488	7.750	8
1905	10,770	47.44	9.123	19.256	9
1906	7200	37.00	6.011	16.241	8
1907	7047	35.91	5.972	16.635	9
1908	10,410	40.50	8.851	21.885	9
1909	851	24.09	.721	2.996	9
1910	1529	26.32	1.296	4.924	8
1911	1630	33.19	1.381	4.161	8
1912	2320	29.29	1.973	6.736	8
1913	4345	38.05	3.836	10.081	8
Mean	5085	34.59	4.318	9.572	



MEAN DISCHARGE OF THE TRINITY RIVER AT DALLAS, TEXAS IN SECOND-FEET.



Run-Off of Trinity River at Dallas, Texas.



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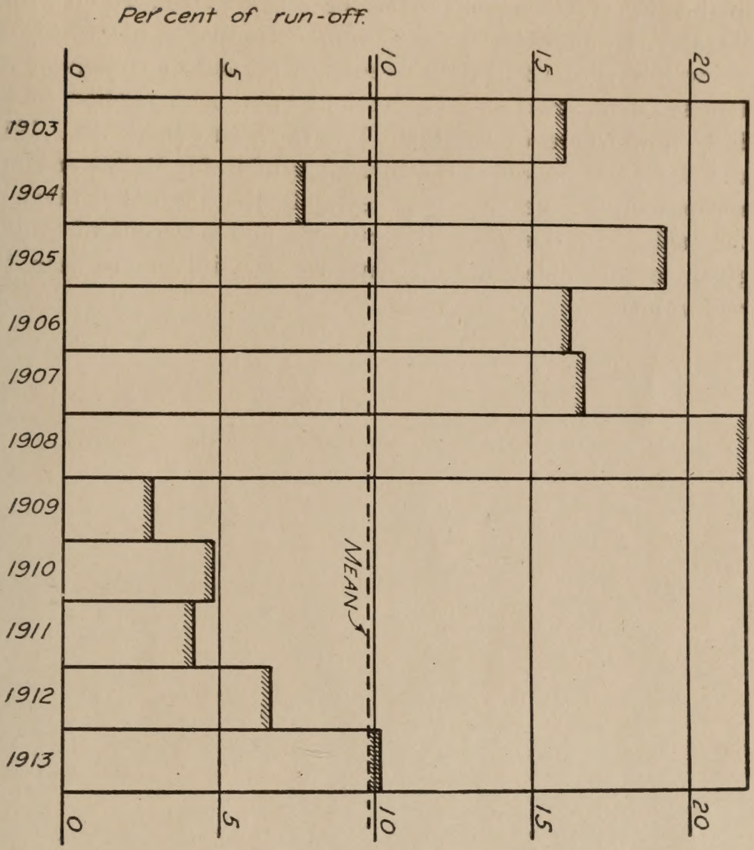

RUN-OFF OF TRINITY RIVER AT RIVERSIDE, TEXAS

In 1908 a dam was erected across the Trinity a few miles below Dallas. When the gates of this dam are closed, it raises the water level at the gauge station near the court house in the city of Dallas and backs the water above zero on gauge. Major T. H. Jackson, of the Corps of Engineers, has furnished the writer with a full daily record of the gate openings at the dam since its erection. Corrections have been applied to the daily flow wherever possible. For the years 1910, 1911, 1912, and 1913, the run-off in the foregoing table for Dallas are only approximate. The run-off is certainly less than that given in the table. In this case the run-off and per cent of run-off given in the table for the years are certainly more than the real values.

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